THE SUN-PATH DIAL.

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The Sun-Path Dial is an adjustable device for demonstrating the course of the sun above and below the horizon of different latitudes at different times of the year.

It consists (see Fig. 1) of a meridian circle with a rotating piece, carrying the equinox and solstice sun-paths—appearing as lines because viewed edgewise—pivoted to its center.

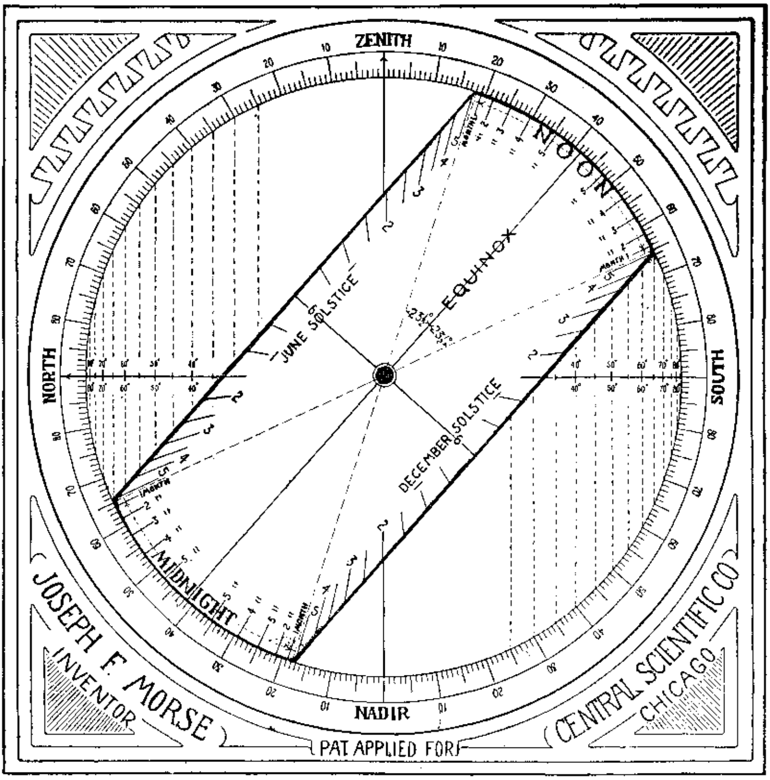

Figure 1.

Supposed observer of sun is at center of dial. His horizon circle also appears as a line because viewed edgewise.

The Sun-Path Dial originated as a *side-view* of the *Heliodon,* or sun-path model—described in a former issue of School Science and Mathematics (June, 1906). The model consists of a horizon *disc* encircled by equinox and solstice sun-path *rings.* In the Dial the disc and rings appear as *lines* because they are represented as viewed *edgewise*—from due west of observer at center of disc.

The Dial may also be thought of as a projection of observer's horizon circle and equinox and solstice sun-paths upon his meridian plane, the projection being viewed from the west.

The Sun-Path Dial is designed for use by pupils in "laboratory" work. By manipulating the Dial, under the guidance of questions furnished by the teacher, the pupil can study out for himself the facts of insolation. He can verify and supplement his observations of the sun at his own latitude, and find out and picture to himself—by pointing successively in the direction of sunrise, the noon sun, and sunset, as given by the Dial—the sun's course as viewed from other latitudes.

Suppose pupil begins his study of the sun-paths at Quito. To adjust for equator he places the rotating piece vertical to the horizon (see Fig. 2). The days and nights are seen to be equal the year through, since the solstice sun-paths (edges of the rotating piece) as well as the equinox line, are bisected by the horizon. The noon sun is shown to be overhead at equinox, $23\frac{1}{2}^\circ$ north of the zenith at the June solstice, and $23\frac{1}{2}^\circ$ south of the zenith at the December solstice. In this—as in every other—adjustment of Dial the equinox sun rises due east and sets due west. The June solstice sun crosses the horizon, in its rising and setting, $23\frac{1}{2}^\circ$ north of east and west, and the December solstice sun $23\frac{1}{2}^\circ$ to the south. By imagining one solstice line shifted slowly to the position of the other and back again the pupil can picture the complete course of the sun during the year as viewed from the equator.

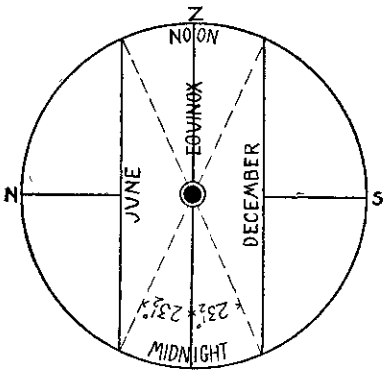

FIGURE 2.

If pupil imagines himself traveling northward from the equator he leans the noon end of the rotating piece southward from the vertical position as many degrees as he goes, gauging by the equinox line. As he does so he will see: (1) that the eqinox line continues to be bisected by the horizon—by construction of

Dial; (2) that the mid-summer days and mid-winter nights grow longer, at an equal rate—the June edge of the rotating piece being thrown more and more above the horizon and the December edge below it; (3) that the rising and setting points of the solstice sun retreat from the east and west, the June sun northward and the December sun southward.

Figure 1 shows the adjustment for 41½° north latitude—say Cleveland. The equinox noon sun is 41½° south of the zenith —by adjustment. The mid-summer sun is 18° from the zenith (41½° minus 23½°), and the mid-winter sun 65° from zenith (41½° plus 23½°). The solstice sun crosses the horizon about 32½° from the east and west, the summer sun to the north and the winter sun to the south. The length of solstice days and nights can be read from the time marks—one half-hour apart—along the edges of the rotating piece. The adjustment for Cleveland throws the June end of the 6 o'clock line three half-hours above the horizon and the December end an equal distance below it. The June solstice days are thus seen to be 15 hours long—the sun rising 3 half-hours before 6, at 4:30, and setting 3 half-hours after 6 at 7:30—and the December solstics days 9 hours long, 6 o'clock, morning and evening, being 3 half-hours below the horizon.

To fix on his own horizon the places of solstice sunrise and sunset given by the Dial, the pupil may temporarily convert the meridian circle into a horizon circle by holding the Dial horizontal with the zenith point to the east. A pencil held to connect the center of the Dial successively with the proper points on the circumference will point for the pupil in the directions of solstice sunrise and sunset. The dotted lines crossing the horizon line at right angles (see Fig. 1) are to guide the pupil in projecting upon the extemporized horizon circle the points of solstice sunrise and sunset given by the Dial.

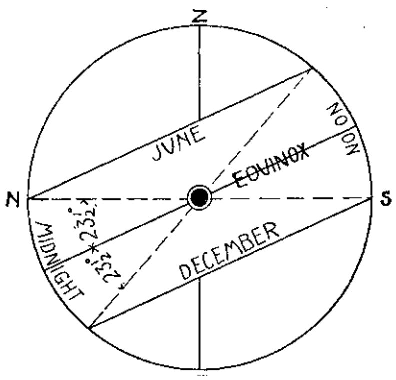

FIGURE 3.

In the adjustment for the Arctic Circle—as Iceland—(see Fig. 3) the June edge of the rotating piece just touches the horizon from above, and the December edge from below—showing a 24-hour day, with the midnight sun on the northern horizon, in midsummer, and a 24-hour night with the noon sun on the southern horizon in midwinter.

Beyond the Arctic Circle the edges of the rotating piece are thrown farther and farther from the horizon, above and below, indicating an increasing period of continuous sunshine in summer and continuous night in winter. By means of month marks along the ends of the rotating piece (shown in Fig. 1) pupil can note the latitudes at which the sun is continuously above the horizon in summer and continuously below it in winter for 1, 2, 3, 4, or 5 months.

At the north pole the sun-paths are parallel with the horizon (Fig. 4) with the equinox sun on the horizon all day, the June solstice sun 23½° above, and the December solstice sun 23½° below. It takes 6 months for the sun to wind its way up from the horizon to the June position and back to horizon again, and 6 months to sink to the December position and return to horizon.

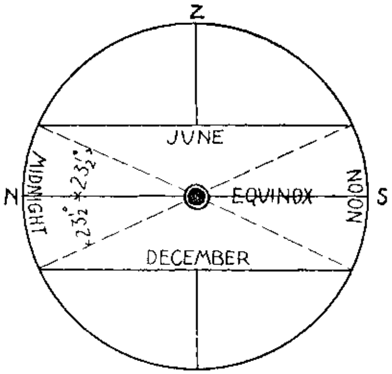

FIGURE 4.

Should pupil travel southward in thought from the equator, he leans the noon end of the rotating piece northward as he goes. This throws the December edge more and more above the horizon and the June edge below it. At the same time the December noon sun is brought nearer the zenith than the June sun. With long days and a high sun in December and short days and a low sun in June the seasons are reversed. The rising and setting points of the solstice sun retreat from the east and west, as when pupil traveled northward, the June sun, as before, crossing the horizon more and more to the north, and the December sun to the south.

In every adjustment the Dial shows the position of the midnight sun—how many degrees it is above or below the horizon, and in what direction.

The length of summer and winter twilight at any latitude can be read from Dial by holding a ruler edge parallel with the horizon and 18° below it and counting the half-hour spaces intercepted between the horizon and the ruler.

The latitude required for any given length of solstice day may be determined from the Dial. Suppose pupil wishes to know at what latitude there is a 20-hour day in midsummer. He inclines the rotating piece until he has thrown 6 o'clock, morning and evening, 4 hours above the horizon, and reads the latitude by noting how many degrees from the zenith the noon end of the equinox line is.

In a similar way the pupil can find the latitude at which the solstice sun rises and sets a given number of degrees—say 60°—from the east and west. The edges of the rotating piece are so placed as to cross the horizon line at 60°, and the latitude read as before.

The Dial may be used to demonstrate the decreasing intensity of slanting sun's rays. For this purpose the rotating piece would represent a shaft of sunlight, which covers more or less horizontal surface (the horizon line) according to its slant. By means of the meridian circle the beam of light can be placed at any angle to the horizontal. Sunshine intensities at different slants can be compared with each other and with vertical sunshine by measuring and comparing the portions of the horizon line covered by the rotating piece in its different positions.

Astronomy pupils can locate the celestial poles for any latitude by extending the 6 o'clock line of Dial to the meridian circle with a ruler edge. The equinox line fixes the position of the celestial equator.

It will be seen from the foregoing description that the Sun-Path Dial shows *how* the sun's course varies with latitude, but not *why*. The Dial is not designed to displace globes and tellurians in the study of seasons, but to supplement them. The usual globe demonstration of seasons views the earth and sun from *space,* leaving the sun's course as seen from different latitudes to be calculated. The Dial pictures the sun throughout as *viewed from the earth.*